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Combined Difference Image and *k*-Means Clustering For SAR Image Change Detection

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***Abstract*— This paper presents an unsupervised change detection method for SAR images based on combined difference image and *k*-means clustering is proposed. The method works in three phases in the first phase wiener filter is used for speckle noise reduction of the two multi temporal SAR images. In the second phase use subtraction operator and the log ratio operator to generate two kind of difference image and apply mean filter and the median filter to these two difference images, respectively. At the final step of second phase, a combinational frame work is used to combine these two difference image to generate combined difference image. At the last phase, combined difference image classified into changed and unchanged area by using K-means clustering with K=2. The programming and simulation of the processes as well as the analysis of the results were done using MATLAB.**

***Index Terms*—SARimage,differenceimage,k-means clustering, change detection**

I. Introduction

Synthetic-aperture radar (SAR) [1]is a form of radar which is used to create images of an object, such as landscape – these images can be 2D or 3D representations of the object. SAR uses the motion of the SAR antenna over a target region to provide finer spatial resolution than is possible with conventional beam-scanning radars. for instance, monitoring via optical images is dramatically reduced by the presence of clouds during flooding or of dust and smoke during volcano eruption. So SAR images are more comfortable than optical images because SAR create high resolution images under all weather conditions. Due to this property of SAR images ,it can be used in many application such as medical diagnosis[2] ,remote sensing[3] , video surveillance[4], natural disaster monitoring[5], agricultural Survey[6], urban change analysis[7] etc.

Change detection based on multitemporal, multispectral, and multisensor imagery has been developed over several decades and provided a timely and comprehensive planning and decision making which aims to identify changes that have occurred between the considered acquisition dates . Synthetic aperture radar (SAR) is a particularly attractive tool for this application. By definition Change detection is a technique that identifying changes by analysing images obtained from the same geographical area at different times. Change detection could be defined formally as a clustering process that classifies input pixels into changed or unchanged categories when given two multitemporal SAR images of the same geographical area. Change detection methods could be categorized as either supervised or unsupervised according to the nature of data processing. The former is based on a supervised classification method, which requires the availability of a ground truth in order to derive a suitable training set for the learning process of classifiers. The latter approach, which is adopted in this letter, performs change detection by making a direct comparison of two multitemporal images considered without incorporating any additional information.

The change-detection process performed by such unsupervised techniques is usually divided into three main sequential steps: 1) pre-processing, 2) difference image generation and 3) analysis of the difference image. The main purpose of step 1 include reduction of noise, geometric and radiometric corrections and coregistration. The SAR images with multiplicative speckle noise is very critical situation because it will make difficulty in change detection task. This is a very critical step, which, if inaccurately performed, may render change-detection results unreliable. In the second step, The two registered and corrected images (or a linear or nonlinear combination of the spectral bands of such images) are compared, pixel by pixel, in order to generate a further image (“difference image”). The difference image is computed in such a way that pixels associated with land-cover changes present graylevel values significantly different from those of pixels associated with unchanged areas.For producing difference image,subtraction operator ratio operator and are most popular techniques. At the final step, change detection is done on the difference image by clustering into changed and unchanged areas. Fuzzy *c*-means , *k*-means , normalized cut , etc. are the different clustering methods.

In this paper an optimal synthetic aperture radar image change detection is achieved by the accuracy of the classification method and quality of the difference image. In order to achieve these two qualities, we propose this change detection method. The main three steps are: 1)preprocessing 2) By fusing a subtracted image and a log-ratio image, difference image is produced and 3) to identify the changed areas in the difference image, by using K-means clustering technique. In order to suppress the multiplicative speckle noise, we are performing wiener filtering of two SAR images getting from same geographical area but at different times . After that subtractor operator and log ratio operators are used to generate the individual difference image . The difference image enhances the background information as well as the changed information The unchanged regions of difference image obtained from subtractor operator are quite rough, and clarity of the image is less, so applying mean filter to difference image obtained by the subtraction operator which will smooth the image. In the case of log ratio image, it is not able to reflect the information of changed regions completely. So applying median filter on the difference image obtained by the log ratio which will preserve the edge information. That is it preserves the shape of the changed area. For producing optimal difference image, it should restrain the unchanged areas information and should improve the information of changed regions. To solve this problem, an image fusion technique is introduced to generate the combined difference image. A combinational frame work uses to combine the two difference image obtained from mean and median filter .Finally, k-means clustering used to divide the combined difference image into changed and unchanged area. The difference image by fusing log ratio image and subtractor operated image contain better information than individual difference image. Among the fusion methods pixel level image fusion is widely used. we can conclude that the difference image that is fused by the mean-ratio and logratio image have better change information than the individual difference information. Combinational frame work has to consider two advantages ;

1) smoothness and local consistency of the difference image obtained by the mean filter
2) preservation of edge information of the difference image obtained by the median filter

The result obtained from this work includes are :

1)By combines the local consistency and edge information of two kinds of classical difference images proposed a new difference image generation framework
2) In the combined difference image the number of missed alarms and false alarms can be tuned and performing k-means clustering via regularization parameter.

This paper has the following structure:section II explains relate works.section III explains the proposed method. The experimental results of the proposed method is given in section IV. Section V concluded the paper.

II. RELATED WORKS

As the use of SAR is widely increased, it is very important to provide continuous monitoring in all weather condition to detect the changes . So that in recent years, detection methods have been proposed to detect the changes within the geographical area between the considered times. In [8] change detection achieved by 2 phases. In first phase, a small number of pixels, which can be labeled as belonging to either ω_c (probability of class associated with changed pixels) or ω_n(probability of class associated with un changed pixels) are selected by using the properties of the difference image together with the prior information. Then, on the basis of such pixels, the initial estimates of these statistical terms are derived. In the second phase (iterative semiparametric optimization), the unlabeled pixels that are located in the middle region of the histogram, and that can turn out to be either changed or unchanged, are used to improve the estimates of the aforesaid statistical terms by performing an iterative process based on the EM algorithm. But it has a limitation of Sufficient spatial resolution required to identify changed area with the required spatial scale.

In [9] generating the *DI* of *I*1 and *I*2 by the NR operator and getting the change detection result by using a threshold algorithm on the *DI*. It have drawback of high false positives (FP) where FP is number of pixels that are detected as unchanged area in the reference image but detected as changed area in the result. All of these drawback of these method overcome by this proposed method by smoothing edge preservation and smoothness terms in combined difference image to avoid missed and false alarm.

III.PROPOSED METHOD

A.CDI-K

The proposed method is also known as CDI-K(combined difference image and k-means clustering)and shown in figure(1).It is explained in 3 steps

1.Image pre- processing

Considering two SAR images *I*1 and *I*2 obtained in the same geographical area with different times. The first step is pre-processing which includes is speckle noise reduction. The presence of multiplicative speckle noise in SAR images makes the change detection much more difficult. It results from random fluctuations in the return signal from an object. It increases the mean grey level of a local area. In order to reduce the speckle noise uses wiener filter. Wiener filter uses pixel wise adaptive wiener method . The denoised images are *X*1 and *X*2 corresponding to *I*1 and *I*2. Wiener filter (a type of linear filter) is applied to an image adaptively, tailoring itself to the local image variance. The restored images by Wiener filter are excellent because Most speckles are removed and the background is uniform.

2. Difference Image Generation

In this step, uses 2 traditional difference image generation operators , are called the subtraction operator and the log ratio operator is generating the individual difference image D_s and D_l respectively.

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$$D_s = |X_1 - X_2| \quad (1)$$

$$D_l = \left|\log \frac{X_2+1}{X_1+1}\right| = |\log(X_2+1) - \log(X_1+1)|. \quad (2)$$

In order to avoid the case that the pixel values in $Xi(i = 1, 2)$ be zeros which make (2) nonsense, use $Xi + 1$.

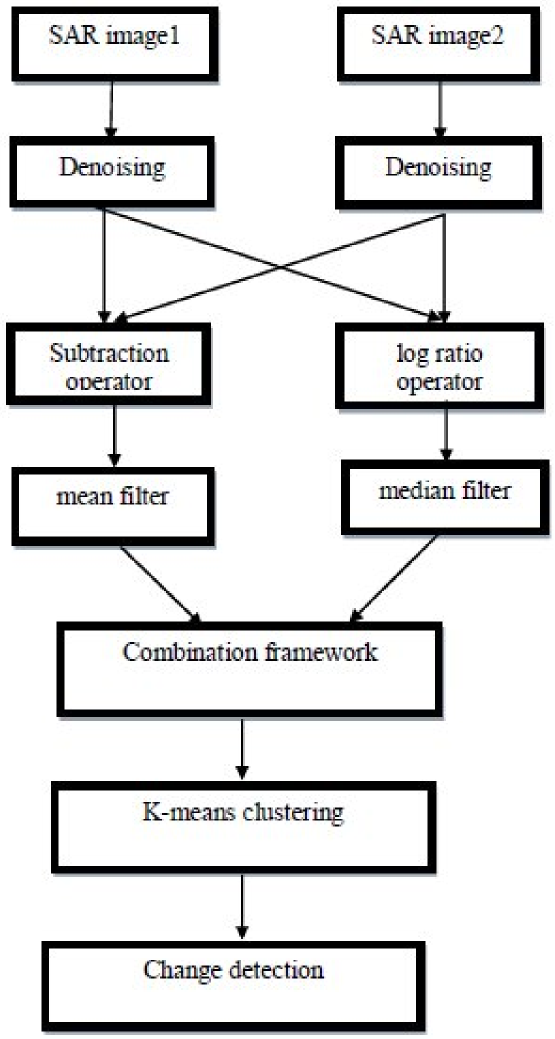

Fig.(1) Blockdiagram of CDI-K

$(i = 1, 2)$ instead of $Xi(i = 1, 2)$ in log ratio operator. For the sequential processing we have to normalize *Ds* and *Dl* to the range [0, 255].

In second half of second step, difference image (Ds)obtained by subtractor operator is passed through mean filter because of there are a lot of isolated pixels in *Ds* and mean filter with a large window size can make the region much more complete and the local area consistent. Then the difference image obtained from log-ratio operator is passed through median filter in order to preserve the edge information. So median filter is suppresing the isolated pixels and preserve the edge pixels.

In final stage of second step, a combinational frame work is used to combine two difference images Ds' and Dl' to generate combined difference image. The combined difference image is generated by using the expression

$$D = \alpha D_s' + (1-\alpha) D_l'. \quad (3)$$

where *Ds'* and Dl' are the obtained difference images after applying mean and median filtering of *Ds* and *Dl*, respectively. This combination is considering two facts smoothness and enhanced local consistency provided by Ds' and the edge preservation by *Dl'*. The mean filter provides many locally smooth regions which have strong local consistency. The median filter has role of edge information preservation and thereby preserving shape of the changed area. In the equation (3),the term $\alpha > 0$ which is known as regularization parameter. This regularization parameter is used for to balance the effects of the smoothness term and edge preservation term and make pixel values in the combined difference image *D* between 0 and 255 By considering equation(3), too large weight for the smoothness term will lead to a large number of false alarms, and too small weight for the edge preservation term will lead to a large number of missed alarms, so the weight should be small for the smoothness term and be large for the edge preservation term. Then the weight of *Ds'* is set as α, and the weight of *Dl'* is set as $1 - \alpha$.

3.Analysing the combined difference image

In last step,k-means clustering algorithm is used to partition the difference image *D* into two clusters: changed area and unchanged area.

B.K-means clustering

Clustering is a process of partitioning or grouping a given set of unlabeled patterns into a number of clusters such that similar patterns are assigned to one cluster. The K-means algorithm is a crisp clustering algorithm, which partitioning collection of *n* vector $\mathbf{x}j, j = 1,\dots,n$ into *c* groups Gi, $i = 1,\dots,c$, and computing a cluster center in each group such that a cost function (or an objection function) measure is minimized.

For a batch mode operation, the K-means algorithm is presented with a data set $\mathbf{x}i$, $i = 1,\dots,n$; the algorithm determines the cluster center $\mathbf{c}i$ and the membership matrix **U** iteratively using the following steps:

Step 1: Initializing the cluster center $\mathbf{c}i$, $i = 1,\dots,c$. This is obtained by randomly selecting *c* points from among all of the data points.

Step 2: Determining the membership matrix **U** by Equation

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$$u_{ij} = \begin{cases} 1 & \text{if } \| x_j - c_i \|^2 \leq \| x_j - c_k \|^2, \text{ for each } k \neq i, \\ 0 & \text{otherwise} \end{cases}$$

Step 3: Computing the cost function (or objection function) by Equation.

$$J = \sum_{i=1}^{c} J_i = \sum_{i=1}^{c} \left(\sum_{k, x_k \in G_i} \| x_k - c_i \|^2 \right)$$

Stop if either it is below a certain tolerance value or its improvement over previous iteration is below a certain threshold.

Step 4: Updating the cluster center by Equation

$$c_i = \frac{1}{|G_i|} \sum_{k, x_k \in G_i} x_k \qquad (3.4)$$

Go to step 2.

In order to see changed and unchanged area more accurately set the gray values in the changed areas to 255 and the unchanged areas to zero.

IV. EXPERIMENTAL RESULT

The proposed technique is simulated on MATLAB R2013a, to justify the effectiveness of the proposed method with two SAR input images. We have 2 SAR image data set. Fig. 2(a) shows the images acquired by the European Remote Sensing 2 satellite SAR sensor over an area near the city of Bern, Switzerland, in April 1999 and Fig.2(b) shows the images acquired by the European Remote Sensing 2 satellite SAR over an area near the city of Bern, Switzerland, in May 1999.

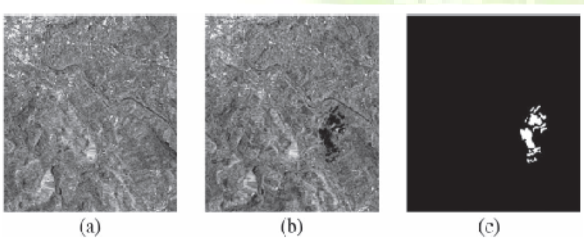

Fig. 2. Multitemporal images relating to the city of Bern used in the experiments.(a) Image acquired in April 1999, (b) image acquired in May1999, and (c) reference

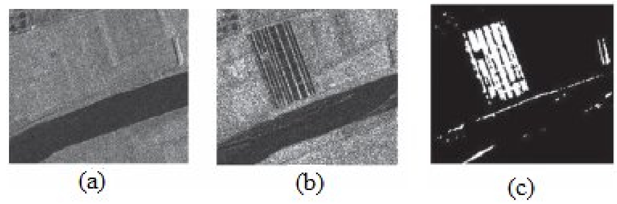

Fig.3 Experimental results on Yellow River data set. (a) Image taken in 2008, (b) image taken in 2009, (c) result by CDI-K

reference image and the output of k-means clustering should be identical to reference image in which white portion shows the changed area and black portion shows unchanged area. Another experimental result of Yellow River is shown in Fig(3). The Fig3(a) is image of Yellow River taken in 2008.The Fig.3(b) is image of Yellow River taken in 2009 and Fig.3(c) result should be obtained by CDI-K. Experimental results obtained on real SAR image data sets confirm the effectiveness of the proposed approach.

A. Applications of Proposed method

Importance of change detection method relies on the possibility of identifying changes that occurred in land-cover changes due to urban expansion, deforestation, floods etc by analysing SAR images acquired at different time but in the same geographical area. So the application of this proposed method are the following:

- Agricultural survey
- forest monitoring
- natural disaster monitoring
- urban change analysis

B. Advantages of proposed method

- Lacking of the ground truth in real applications makes the unsupervised approaches much more popular
- This approach has better performance in the preservation of changed area
- It does not require any prior information
- The unsupervised approach simply provides a "change alarm" to highlight areas of change for further investigation
- In the case of supervised method, generating training data at global and regional scales is a very labour-intensive and costly which makes an unsupervised approach to automated land cover change detection a more attractive option.

V. CONCLUSION

This paper has focused on making SAR image change detection by using combined difference image and k-means clustering. it mainly consists of three steps including image pre-processing. Obtain the difference image and identifying the changes. This is the unsupervised method.

For better difference image representation, uses the local consistency of the difference image after using the mean filter and the edge information preservation of the difference image after using the median filter.
The use of SAR data in monitoring and detecting changes is beneficial and advantageous especially if SAR data integrated with optical data it becomes more powerful. Understanding the environment (target) that SAR will be used in, is very helpful to detect and interpret the results. Combination technique can be combine other methods for monitoring changes based on study area conditions, also can develop new algorithms based on which combination would be used.

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